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HANDLING STRAWBERRIES FOR FRESH MARKET

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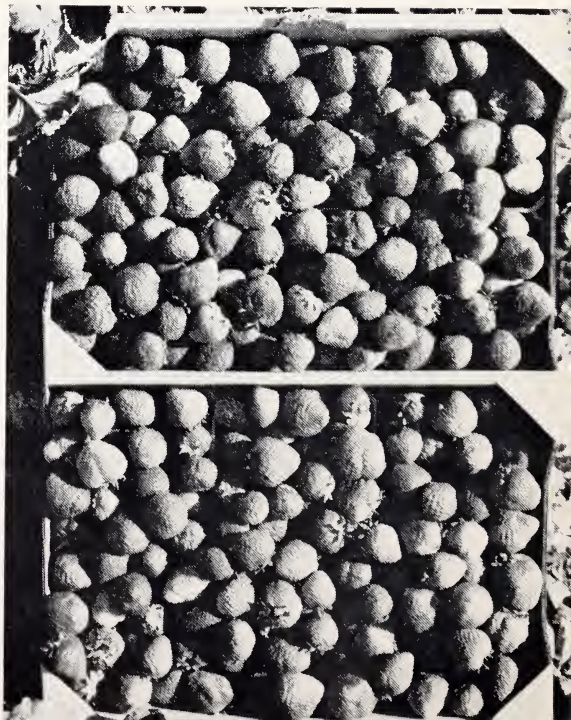


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Did you know that . . .

- An estimated $5,000,000 worth of California strawberries are discarded between the field and the table each year?
- Each handler of strawberries, from the grower to retailer, may do damage which he does not see?
- Deterioration can come from three sources—injuries, self-destruction and decay?
- Any program aimed at reducing market losses of strawberries must start with careful picker training and supervision?
- Berries held at 50° F will last only one fourth to one half as long as fruits held at 32° F?
- Berries exposed to the sun after picking quickly reach temperatures considerably above air temperature?
- Short delays at field temperatures before cooling will reduce the amount of marketable fruit?



Properly harvested crate of high quality strawberries.

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HANDLING STRAWBERRIES FOR FRESH MARKET

F. G. MITCHELL · E. C. MAXIE · A. S. GREATHEAD

THIS CIRCULAR is intended as a guide for growers, shippers, and other handlers of fresh strawberries. It tells how to prepare and handle California strawberries for fresh market. Advice given will pertain to berries going into any fresh outlet but certain steps in the operation may not be as critical when the berries are marketed locally (and quickly).

High fruit quality in the market is only possible if fruit of high quality is produced in the field. This places responsibility on the grower to use good cultural practices, such as irrigation, fertilization, weed control, pest and disease control, and to carefully supervise field operations to correct problems before they may affect fruit quality. (Alderman *et al.,* 1962, and Holland *et al.,* 1962).

THE PROBLEM

STRAWBERRIES are one of the most perishable of all fruits. They are essentially full-ripe at harvest as opposed to many other fruits that are picked "green" and ripened later. They have a high rate of metabolism (they "live fast") and will destroy themselves in a relatively short time, even without the presence of decay organisms.

Strawberries are living organisms. As all living things they must stay healthy, for their health determines the quality of the fruit the consumer receives.

The structure of the strawberry makes it vulnerable to spoilage. It has a thin, tender skin that is easily broken. The seeds are easily torn away, and the flesh of the fruit is soft, allowing it to be easily crushed and bruised. Any injury may invite an attack by decay organisms to which this fruit is very susceptible.

Thus, the strawberry fruit, having a high rate of metabolism, being susceptible to injury, and vulnerable to decay organisms in the field, is ready prey to many postharvest ills. Losses of California strawberries destined for eastern markets are staggering. During recent years it has been estimated that the equivalent of the yield of 2,000 acres become inedible annually before reaching the consumer. This means that $5,000,000 worth of our strawberries are discarded between field and table each year. In addition, a very important, but undetermined loss is the reduction in quality of fruits that are consumed, and its effect on sales volume and price.

Strawberry fruits begin to lose quality before they are harvested. When the sun rises on a field of strawberries

the ripe fruits start to deteriorate by decay or internal breakdown, and this deterioration continues until the fruit is eaten. The quality of the fruit when the consumer receives it, or even whether the fruit ever reaches him, depends on how good a job is done by the various handlers.

Each handler of strawberries, from the grower to the retailer, may do damage he does not see. Since the damage does not appear while the fruit is under his control he may not be held immediately responsible for it. However, any damage which results in loss of fruit or quality will affect ultimately the returns of all handlers of strawberries.

Importance of Temperature

The most important way to slow down spoilage of strawberries is to remove field heat and maintain the fruit at a low temperature. For maximum life, keep strawberries as close to 32° F as is practical.

Why is temperature so important? As stated before, a strawberry fruit will destroy itself even if it is free of disease organisms. When the temperature of a strawberry is raised from 32° to 50° F its rate of deterioration will increase two to four fold. *This means that fruits at 50° F have a life expectancy of only one fourth to one half that of fruits at 32° F.* If the temperature of the fruit is around 85–90° F, as may happen in packed berries left in an open field, the market life of the fruit is reduced to only a few hours.

Relative Humidity

The relative humidity at which strawberries are held will affect their weight loss and appearance. While relative humidities approaching saturation (100 per cent) may promote the development of decay organisms, too low a relative humidity for any extended period will increase weight loss and may quickly make the fruit look old and shriveled. To avoid this, hold the relative humidity at approximately 90 per cent.

Fruit Rots (Wilhelm, 1961).

Another important source of strawberry spoilage is fruit-rotting organisms. Fruit-rotting fungi can grow rapidly in a basket of berries and destroy the fruit. The rate and amount of decay in fruit may be greatly increased by injuries during picking or handling, and by delayed cooling.

Gray mold rot, caused by the fungus *Botrytis cinerea* Pers., is the most common of the fruit rots. Field infection by this organism is favored by cool, wet conditions. It is most serious during rainy periods and during cool, wet, or foggy weather. The organism causing the disease is present in every strawberry field at all times. It is the most common organism found in older leaf tissue. The disease causes severe losses in the field before harvest and also in storage and transit of the harvested fruit. Since the organism is able to penetrate the unbroken skin of the berry, one decayed fruit can lead to the decay of surrounding fruit, producing a "nest" of decayed berries.

An infected fruit first shows soft, dull colored spots. Later the fungus coats the fruit with its gray growth. During picking, spores from moldy fruit may contaminate healthy berries. Rotting may continue during transit and marketing, and any injury inflicted during picking or handling will favor the disease. Usually, gray-mold problems have their origin in the field.

A second disease of stored fruit is caused by the fungus *Rhizopus stolonifer* (Ehr. ex Fr.) Vuill. (= *R. nigricans* Ehr.) This disease is favored by high temperatures and humidity. Like gray

mold, it causes severe losses in the field as well as in storage. Infected fruit is soft and watery, giving rise to the name "leak." Under conditions of high humidity, the organism will produce a long whiskery type growth on infected fruits, and like gray mold the organism can move from infected fruit into adjacent healthy fruit, producing the nesting effect.

While there are no commercial means of completely eliminating fruit rots, growers, shippers, and handlers can do much to minimize losses. For instance:

- Remove from the plant all fruit (green or ripe) showing signs of decay at each picking.
- Do not put any fruit showing decay into the crate. Fully instruct pickers accordingly.
- Apply fungicides in the field to reduce decay in field and storage. Consult the current University pest and disease control recommendations for detailed information.
- Cool the fruit as soon after harvest as possible and keep it cool. The lower the temperature, the slower the advance of these decay organisms. For best control, hold fruit as close to 32° F as possible.



HARVESTING AND FIELD HANDLING

PROPER SUPERVISION of the entire harvest operation is essential. This must include supervision of all aspects of the harvest—picking, field handling and local transport to the cooler.

Field supervision may be handled by the owner or manager of a small operation or by hired foremen of larger operations. Whatever the arrangements, these field bosses must be

Picking crew at work in strawberry field. Picking from only the half of the bed nearest to picker eliminates excessive reaching and simplifies selection of ripe berries.





Field picking of strawberries, showing desirable crate and basket arrangement. Note picking stand to keep crate out of dirt. The picker is picking, sorting, and packing in one operation, avoiding unnecessary handling. Picking from only the half of the bed nearest to picker eliminates excessive reaching and simplifies selection of ripe berries.

under careful control of management since their activities will have profound influence on the shipping quality of the fruit.

Picking

Strawberries are harvested at different stages of ripeness, depending on the time and distance to market (Holland *et al.,* 1962). Fruit for local market should be fully ripe and firm while fruit for long distance shipment should be picked at the pink or three-fourths colored stage.

Strawberries in California are almost universally shipped in fiber crates holding 12 one-pint baskets. Three main types of baskets are used—molded plastic, paper, and wood veneer. The plastic baskets are open for air movement and for visual inspection by the consumer. Paper baskets do not allow visual inspection, but provide some cushioning protection against rough handling. Wood-veneer baskets, no longer the primary container, are now used mainly for local-market berries. The fruit is picked directly into the crate in which it is to be shipped.

The following steps are important for pickers (Mitchell and Greathead, 1959):

- Always use a picking cart or stand, to keep the crate off the ground.
- Handle the full crate very gently. The tender fruit is very easily bruised.
- Be careful that feet and knees do not injure any green fruit hanging in the furrow. This can reduce the quality of later harvests.
- Pick berries with the caps (or calyx) on. Take hold of the fruit gently between the thumb and first two fingers. With an upward or forward twist of the wrist, snap the stem off. Pick special stem grade fruit by pinching the stem one to two inches from the calyx.
- Hold the fruit loosely in the hand without squeezing. Remember that any time you squeeze the fruit it is bruised and will discolor, so HANDLE IT GENTLY. Place the fruit in the crate—do not drop it. Do not hold too many fruit in the hand at one time.
- Throw away any berries showing rot, sunburn, insect injury, severe misshape, and also soft and overripe berries. Remove all of these berries from the plant and place them in the bottom of the furrow. If the cap has been removed accidentally, discard the berry.
- Do not fill the crates so full that berries will be crushed when crates are stacked.



Selection of berries by a careful picker resulted in 14.4 per cent unmarketable fruit (left) while a careless picker caused 33.7 per cent of the berries to be unsalable.

Picker damage can nullify all other attempts to maintain fruit quality. To check importance of picker damage, a test was set up to compare the level of marketable fruit from pickers with different abilities at picking, sorting and packing. Two pickers, selected by the grower, were set side by side in the field but were not told that their fruit was part of a test. Five crates were taken from each picker, identified, and then held for eight days at 41° F before sorting. The more careful picker's lot contained 14.4 per cent unmarketable fruit compared to 33.7 per cent for the less careful picker. This illustrates a wide variability in the care exercised by pickers. Any program aimed at reducing market losses of strawberries must start with thorough picker training and supervision.

The experienced picker will snap fruit without bruising the berry or breaking the cap.



Field Handling and Hauling

Problems in field handling of strawberries can include physical damage and inadequate protection against high temperature or delayed cooling. Most growers make a real effort to avoid rough handling of their fruit during picking, stacking, and loading. However, they may overlook good temperature management because the end results are not so immediately apparent. Nevertheless, temperature management in the field can strongly influence the ultimate quality and shelf life of the berries (Maxie *et al.*, 1959*a*, 1959*b*).

To determine the importance of temperature in strawberry management, it is necessary to understand the effect of temperatures on strawberry deterioration.

Temperatures actually attained in the field

The upper left graph on page 9 shows the temperatures of strawberries in different positions in the crate and in shaded and sunny locations. Note the definite advantage of shading. Strawberries exposed directly to the sun quickly reach temperatures considerably above air temperature because their dark color readily absorbs heat from the sun. During long exposure, even berries in shaded positions ultimately reach temperatures approaching that of the air. You will face this situation under normal field conditions where temperatures are fairly high.

Effect of high temperatures on the berry

The upper right graph on page 9 shows the respiration rate of Shasta strawberries held at temperatures ranging from 32° to 100° F. As respiration rate roughly equals the rate of living of the berries it obviously is to your advantage to hold fruit at lower temperatures. Note the rapid drop of the respiration rate at higher temperatures, due to destruction and death of the tissue. It is important, therefore, to reduce the temperature of the fruit as soon as possible after harvesting.

Some growers hold their fruit in the field for prolonged periods. Obviously, at extremely high temperatures this will lead to rapid destruction of the fruit. However, if you pick the berries when it is fairly cool and if you shade them in the field, you can slow down their destruction to some extent. But they may warm up rapidly as a result of a warm summer breeze or during their transport on an open flat bed truck to the shipper's facility (lower left graph on page 9). An air velocity of just five miles an hour, a very mild wind, warms the fruit nearly to air temperature in 20 to 30 minutes. This rapid warming results from an unlimited supply of warm air passing directly over the fruit. As a result of cooling by the evaporation of water from the fruit, berries in the center of the basket, somewhat protected from air, are not warmed to the air temperature. This water loss, however, causes further reduction of fruit quality. A substantial temperature rise during a very short period of open transit will take hours to overcome in the normal pre-cooling facility, where both refrigeration capacity, air flow are limited.

To check the effect of delays in cooling upon marketability, berries were held for different periods of time following harvest at 85° F and then rapidly cooled to 40° F. The lower right graph on page 9 shows the results of grading the berries after a week at 40° F. A very rapid reduction in the amount of marketable fruit resulted from holding the fruit at 85° F before cooling.

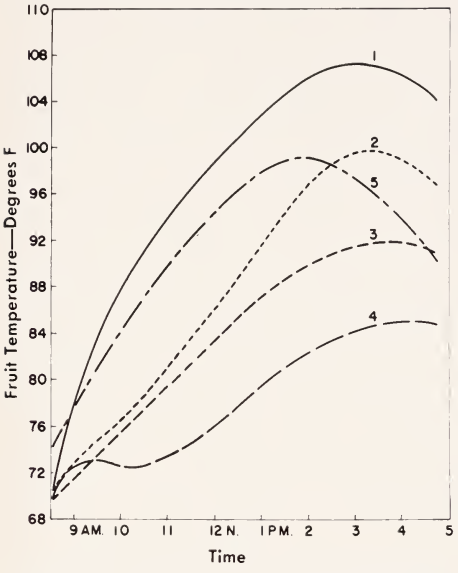
Pickup and loading is done close to the pickers and with as little delay as possible. Note the inverted crates used for shading stacks on the ground.



Tests with Shasta Strawberries advise:

KEEP STRAWBERRIES COOL AFTER PICKING!

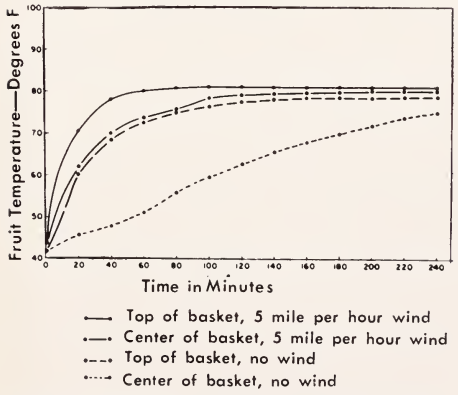
Shade crates in the field



1—Fruit, top of basket in sun; 2—Fruit, bottom of basket in sun; 3—Fruit, top of covered basket; 4—Fruit, bottom of covered basket; 5—Air, in sun.

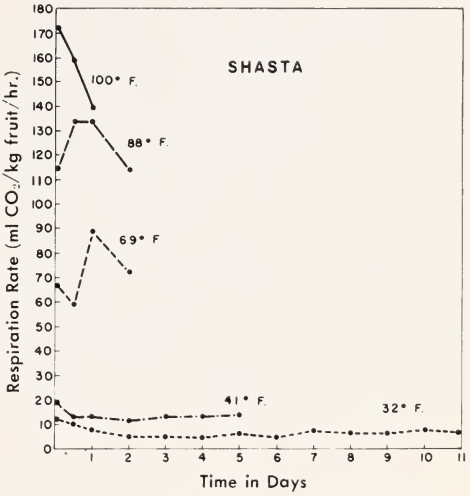
Simulated tests show that berries crated in the field should not remain uncovered in the sun.

Berries warm up after harvest



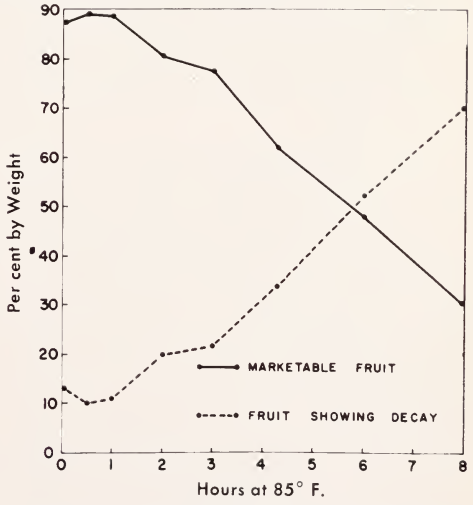
Berries transferred from 41° to 85° F will warm rapidly (regardless of location in basket) in a warm summer breeze. Berries on top of basket will warm rapidly even with no breeze.

High temperatures will "kill" berries



The influence of temperature (32° to 100° F) on respiration rate—which is a measure of the rate of living. The higher the temperature the shorter the life.

Don't delay cooling



Very short delays before cooling to 40° F resulted in sizable losses in marketable berries.



Loading strawberries in field.

SHIPPING

THE SHIPPER and the carrier are responsible for good handling practices as soon at the fruit is under their control. They, too, have to watch out for physical handling and temperature management.

Cooling and Holding

As indicated before, berries should move as quickly as possible from picking to cooling. Rapid cooling will also further decrease the time during which the berries are exposed to higher temperatures. Forced-air cooling, a recent development now in commercial use, appears promising in greatly reducing the time for cooling (Guillou, 1960).

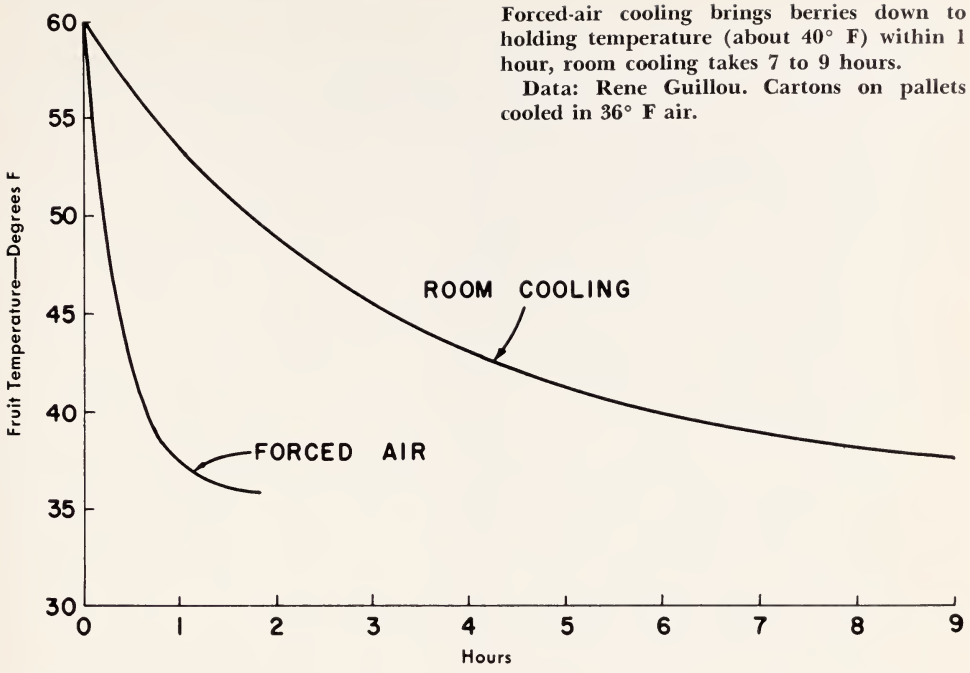
Forced-air cooling is a method whereby the air is forced to pass through the container and around the fruit. By comparison, standard cooling is accomplished by passing the air past the crates or pallets with little air passing through the container. With forced-air cooling, the time required to lower the temperature of the fruit for transit is reduced to one-sixth to one-eighth of the time required under standard cooling conditions. As the upper graph on page 11 shows, in one test a cooling period of 7 to 9 hours was required under standard cooling conditions, while forced-air cooling required less than 1 hour.

To assess the advantages of the handling and cooling procedures of strawberries, a series of trial shipments were conducted. Rapid handling and thorough forced-air cooling were combined as one treatment and compared to fruit handled in the normal manner. In all cases, the fast cooled lots reached 40° F within approximately 1 hour after picking. In contrast, the normally handled fruit required from 8 to 14 hours between picking and the time the fruit reached 40° F. Fruit temperatures at the time of harvest for the various trials ranged from 68° to 84° F. In each case, marketability was increased by the rapid handling of the fruit. The increase ranged from 8 to 21 per cent.

The lower graph on page 11 shows the over-all results of grading following arrival of the fruit in terminal markets. The fast cooled lots had approximately 1 additional day of shelf life at time of arrival, and their rate of deterioration following arrival was slightly slower than the rate of deterioration of the normally cooled lots (Mitchell *et al.,* 1961). This shows a real advantage in terms of increased marketable fruit resulting from good management during handling and cooling of strawberries.

Because they are extremely perishable, strawberries should be marketed as rapidly as possible after harvest. This is particularly important for fruit destined for eastern markets where the

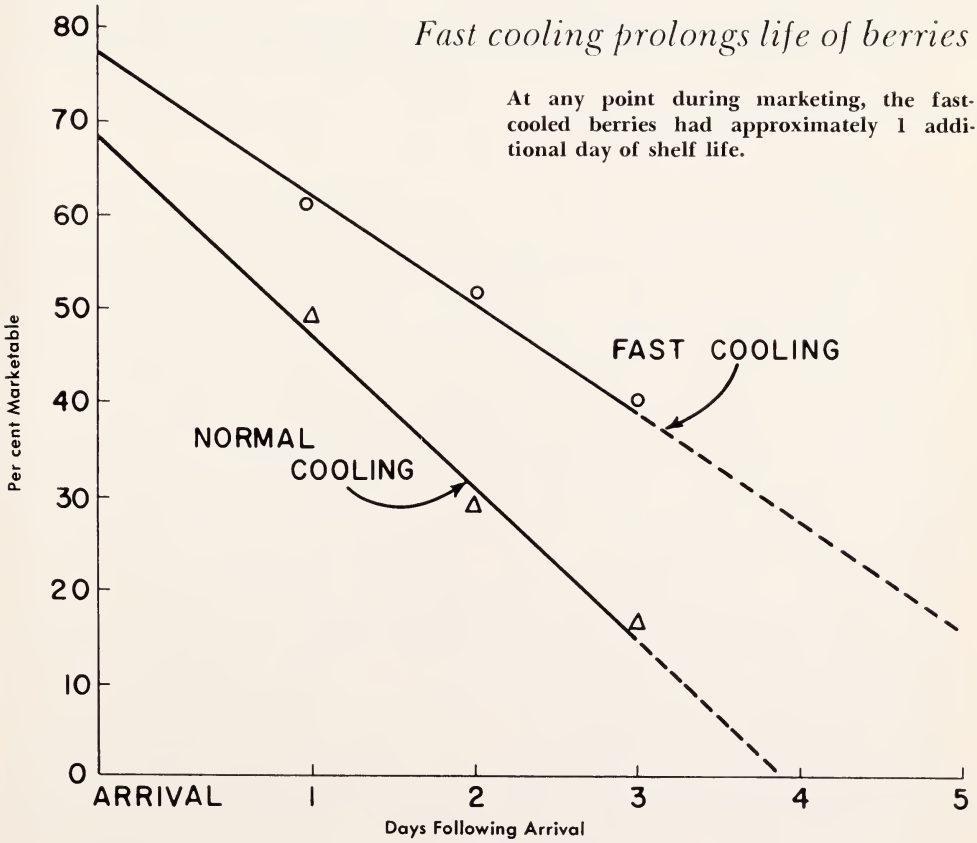
Forced-air speeds cooling



Forced-air cooling brings berries down to holding temperature (about 40° F) within 1 hour, room cooling takes 7 to 9 hours.

Data: Rene Guillou. Cartons on pallets cooled in 36° F air.

Fast cooling prolongs life of berries



At any point during marketing, the fast-cooled berries had approximately 1 additional day of shelf life.



On arrival at the cooling plant pallets are used to transfer fruit from the truck to the cooler. This reduces handling delay and damage.

transit period may take as long as one week. If holding is necessary, keep the time as short as orderly marketing allows.

During such holding periods, maintain the temperature of the fruit at 32° F. It may be difficult to maintain the desired low temperature of storage fruit if warm fruit is introduced into the same room. If you use forced-air cooling, you can pass the cold air across the storage fruit before it passes through the warm fruit. If constant in-and-out traffic is necessary in a room in which cold fruit is being held, you may consider the use of air "curtains." This directed flow of air across the door opening reduces the mixing of the cold and warm air on either side.

Loading and Transportation

The loading of berries for transport to market must receive the same care as all other steps in the marketing process. The personnel has to be adequately trained and supervised to avoid rough handling of the berries. Warming of the fruit during loading must be prevented since it may cause fruit sweating and will necessitate additional cooling to remove any absorbed heat. The carrier vehicle should be pre-iced and cooled before loading starts. The cold room should be located close to the loading docks and fruit moved directly from storage to rail car or truck. If possible, protective loading curtains or tunnels between

these points should be provided to reduce heat leakage.

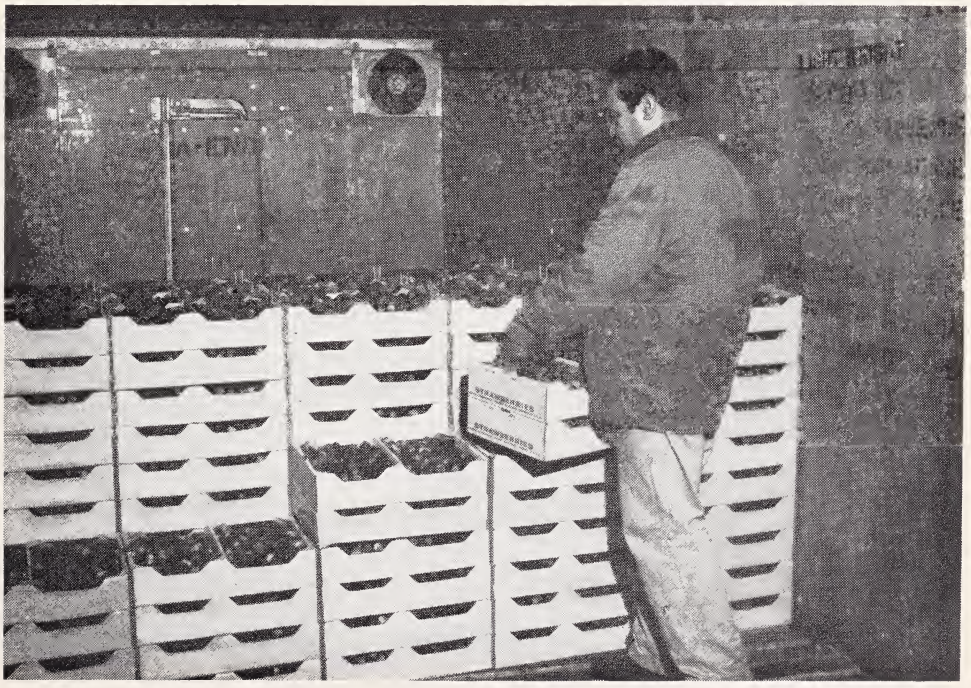
While the main cooling is accomplished by water ice, it is common practice to place approximately 1,000 pounds of dry ice in a paper-lined crib atop the center brace of the car. This is done just before closing the doors on a rail car after loading (Allen *et al.*, 1944; Ryall, 1956*a* and *b*). Studies have indicated that the closest point of the crib should be at least 8 inches from the berries to avoid freezing of the fruit. The paper wraps on most of the cakes of dry ice are left intact to lengthen the effectiveness of the treatment. Sometimes, an additional 200 pounds are broken up and "salted" into the ice bunkers.

The primary purpose of the dry-ice treatment is to build up the carbon dioxide concentration of the atmosphere within the car. Several studies have shown that a carbon dioxide concentration of 10 to 20 per cent is beneficial for the strawberries—it slows their respiration and the growth of decay organisms so that the fruit may arrive in market firmer, brighter and with less decay than nontreated berries.

Studies on the effectiveness of this dry-ice treatment have indicated that an initial concentration of 10 to 20 per cent carbon dioxide is reached within three to four hours, and that the possibility of maintaining a satisfactory concentration depends on the tightness of the equipment. The dry ice which is salted into the ice bunkers helps to build the initial concentration.

As soon as the fruit is properly loaded and the dry ice is in place, the car doors should be closed and remain closed until arrival. The car fans should be started and run continuously until rail transit begins. In mechanical refrigerator cars, trucks, or cars equipped with a supplemental

Correct method of loading strawberries in refrigerated car. Crates are stacked so that wire support (seen sticking out on top of the load) reinforces the stacks. The strong ends of the containers parallel the direction of car movement, thus reducing possible damage to the containers.





Dry ice is used to increase carbon dioxide in the car atmosphere thus reducing spoilage and delaying ripening during transit. Paper is wrapped around most of the cakes to make the carbon dioxide last longer. Note the covers on the first three tiers next to the brace to help protect fruit against freezing.

power supply the fans should be run thermostatically until unloading.

The standard procedure in shipping strawberries by rail is to fill the ice bunkers with ice and add 2 or 3 per cent salt prior to loading, to replenish ice and salt after loading, and to re-ice enroute at designated icing stations (Ryall, 1956*a*). The requirements for icing and salting will vary with the outside temperature enroute — a higher percentage of salt and more frequent re-icings are to be used during hottest weather. The dry ice adds some refrigeration, and the amount of salt required to maintain the desired temperature may be reduced with dry ice.

While it is desirable to keep strawberries near 32° F to hold down decay growth and fruit respiration, care must be taken to prevent freezing the fruit. The freezing point for strawberries has been reported as approximately 30° F. This will vary with variety, growing conditions, and ripeness of the fruit. Because of constantly changing climatic conditions during the season and differences in available equipment, the shipper must become experienced in designating the icing procedure for strawberries. The many variables make it difficult to make a standard recommendation regarding the percentage of salt or re-icing schedule.

TERMINAL MARKET HANDLING

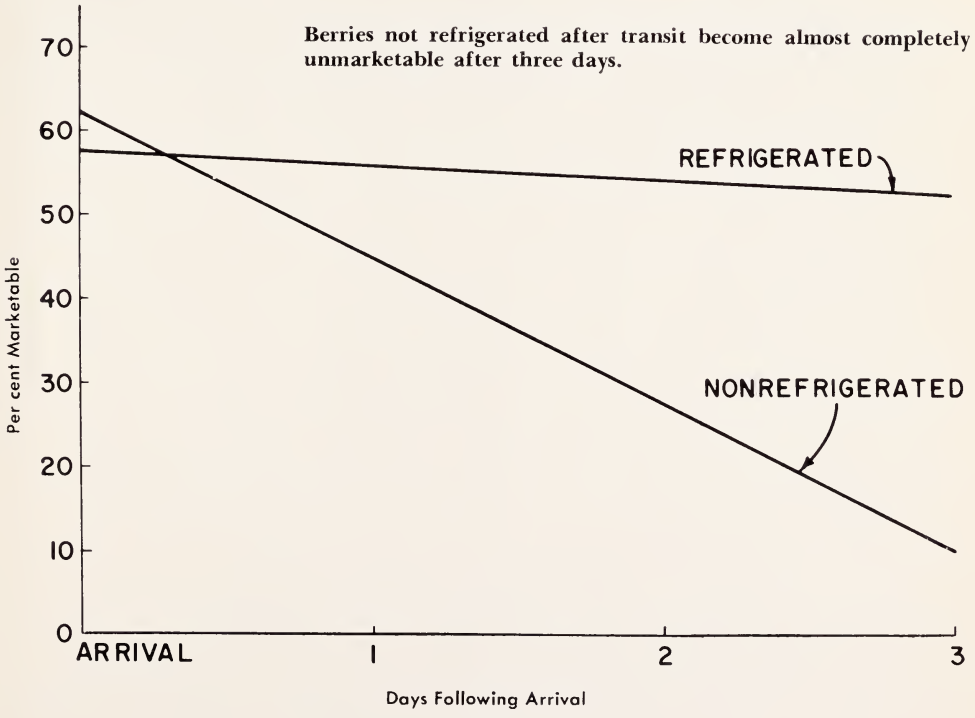
THE PROBLEMS of handling strawberries during wholesale and retail are similar to those during other stages of marketing (Mitchell and Maxie, 1962). Here, too, deterioration can come from three sources—injuries, self-destruction, and decay. Terminal market handling must try to keep these three sources down.

Rough handling cannot be tolerated at any step in the market process, and becomes even more critical at the marketing phase. As the berries move through the distribution channels they become older, riper, softer, more delicate, and more subject to handling damage. Thus, good training and supervision are needed to prevent rough handling.

Temperature management remains important at this stage of marketing. This is the only practical means of holding self-destruction and decay losses to a minimum. Under commercial conditions, berries are often exposed to relatively high temperatures during unloading and handling in the warehouse and during transit to the retail store. The effect of such conditions on the warming of the fruit was shown earlier in the left bottom graph on page 9.

This warming has a similar result as that of delays in the field before cooling. A test was made to determine the importance of temperature at wholesale and retail levels. No one questioned that the nonrefrigerated berries would deteriorate more rapidly, but the difference in rate was startling. As shown in the graph on this page, about 50 per cent of the re-

Refrigeration during marketing saves fruit



frigerated fruit was still marketable after three days while the nonrefrigerated fruit was almost completely destroyed during this period.

For proper temperature management in the terminal market:

- Refrigerate at all times at 40° F or below; if fruit must be held longer than one day, reduce the temperature to 32° F.
- Avoid unnecessary delays which keep fruit out of refrigeration.
- Provide refrigeration in transit from receiving warehouse to retail store.
- Use refrigerated display if possible; if this is not possible avoid displaying more than a few hours' supply at any time.
- If the berries become warmed, cool them as rapidly as possible by good positioning in the cold room.

Publications mentioned in this circular:

Alderman, D. C., A. S. Greathead, and E. C. Koch.
1962. Strawberry production in Central California. U.C. Agr. Ext. Ser. AXT—80.

Allen, F. W., W. T. Pentzer, and C. O. Bratley.
1944. Carbon dioxide investigations: Dry ice as a supplement to refrigeration of plums in transit. Proc. Amer. Soc. Hort. Sci. 44: 141–47.

Guillou, R.
1960. Coolers for fruits and vegetables. U.C. Agr. Exp. Sta. Bull. 773.

Holland, A. H., Hunter Johnson, Jr., and Bernarr J. Hall.
1962. Strawberry production in Southern California. U.C. Agr. Ext. Ser. AXT—50.

Maxie, E. C., F. G. Mitchell, and A. S. Greathead.
1959*a*. Quality study on strawberries. Calif. Agriculture 13(1), pp. 6, 15.
1959*b*. Studies on strawberry quality. Calif. Agriculture 13(2), pp. 11, 16.

Mitchell, F. G., and A. S. Greathead.
1959. How to pick strawberries. U.C. Agr. Ext. Leaflet, unnumbered.

Mitchell, F. G., H. L. Hall, A. H. Holland, and A. S. Greathead.
1961. Strawberry marketability. Calif. Agriculture 14(2), pp. 13–14.

Mitchell, F. G., and E. C. Maxie.
1962. Maintaining strawberry quality in the market. Produce Marketing 5(5), pp. 41–42.

Ryall, A. L.
1956*a*. The effect of bunker salting, dry ice and air circulation on temperatures in express shipments of fresh strawberries. Third Conference Proceedings, Transportation of Perishables Conf. pp. 73–76.
1956*b*. Precooling and transit temperatures of strawberries. Third Conference Proceedings, Transportation of Perishables Conf. pp. 151–153.

Wilhelm, Stephen.
1961. Diseases of strawberry. A guide for the commercial grower. Calif. Agr. Exp. Sta.–Ext. Ser. Cir. 494.

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